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WHITE RIVER SHALE PROJECT

TRACE ELEMENT ANALYSIS

FEBRUARY 1976

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WHITE RIVER SHALE PROJECT

TRACE ELEMENT ANALYSIS

FEBRUARY 1976

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WHITE RIVER SHALE PROJECT

TRACE ELEMENT ANALYSIS

February 1976

SCOPE:

As stipulated in Section II of the "Partial Exploration Plan Environmental Baseline Data Collection and Monitoring Element Document" approved November 20, 1974, an in-depth series of trace element analyses were performed on material intercepted during the recent Ua and Ub exploration program.

Part II-F, "Core Evaluation" called for analyses of raw shale for the following trace elements throughout the drill hole total depths:

a) Boron

b) Mercury

c) Cadmium

d) Fluoride

e) Antimony

f) Arsenic

g) Selenium

The attached presents the results obtained, along with a detailed statistical evaluation, showing that further trace element analysis work would be redundant.

SUMMARY:

The results of the latest trace element analysis of samples from the exploration drill holes have been received from Ute Research Laboratories, Fort Duchesne, Utah. The material analyzed consisted of both raw shale and spent shale samples from the expected mining horizon in all nine exploration drill holes, as well as a series of overburden samples from drill hole X-1. These test results have been statistically analyzed to demonstrate compatibility with earlier test results.

Statistical evaluation of these results was accomplished primarily through use of the t-test. After computation of the means and standard deviations of a group of samples, the t-test can be used to provide a measurement of the relation between a sample and the general population as a whole. Based on the sample's mean and standard deviation, an interval can be calculated within which the true mean of the population can be said to lie with a certain degree of confidence. This "confidence interval" has been calculated for these data with a .95 probablility of being accurate and is listed in the attached tables. In addition, the t-test can be used to compare one sample to another. By calculation of a pooled estimate of standard deviation, it is possible to determine whether the difference between the means of two samples is due to the samples having come from separate populations or is simply a reflection of the uniqueness of individual samples. The t-test gives a measure of the significance of this difference and a confidence level at which the two samples can be taken as representative of the same general population.

SUMMARY (Continued):

Table I compares the analysis of overburden material from drill hole X-1 to earlier results from the four pilot holes. By employing the t-test, it can be shown, with a .05 chance of error, that samples from drill hole X-1 and the "P" holes represent the same general population. Since the results on hand, then, represent the general concentrations across Tracts Ua and Ub, overburden samples from the other drill holes could be expected to exhibit similar correlation.

Tables II and III concern samples of raw shale from the expected mining horizon. Table II compares the results from all nine exploration drill holes to an earlier analysis of samples from the four pilot holes. Once again, a high degree of compatibility can be seen in the results and the t-test indicates that both sets of figures are representative of the same general population (with a confidence level of 95%). Table III compares the combined figures for the exploration and pilot drill holes with those reported by Desborough, Pitman and Huffman in the U.S.G.S. Open-File Report 74-77 for two core holes located 26 and 36 miles southwest of Tract Ua.

Analysis of spent shale samples from the expected mining zone shows losses due to retorting as well as the trace element levels in the material that is to be deposited on the surface. Table IV compares trace element levels in raw shale with both total trace element and water soluble trace element levels in the corresponding spent shale. Table V gives spent shale results in detail.

Statistical analysis of the data presented by Ute Research Labs reveals close correlation between the results from the exploration holes and

SUMMARY (Continued):

the pilot holes. The t-test indicates that, in 95% of the cases, any further testing would not produce significantly different results and it is therefore recommended that the data on hand be accepted as representative of the general concentrations to be found across Tracts Ua and Ub.

CALCULATION METHODS:

I. Definitions:

1. N = Sample Size

2. Σx = Summation of individual element values from samples.

3. Σx^2 = Summation of squares of individual element values from samples.

4. t = Tabulated value relating to N-1 degrees of freedom and 95% confidence level.

II. Calculations:

1. Mean: $\bar{x} = \Sigma x/N$

2. Estimated population standard deviation:

$$S(x) = \sqrt{\frac{\Sigma x^2 - \bar{x}\Sigma x}{N-1}}$$

3. Estimation of population mean (confidence interval):

$$M = \bar{x} \pm t\,(S(x)/\sqrt{N})$$

Interpretation: Given the tabulated value of t, there is a 95% probability that the population mean, M, lies within the interval $\left[(\bar{x} - t\,(S(x)/\sqrt{N}),\ \bar{x} + t\,(S(x)/\sqrt{N})\right]$

4. Pooled estimate of standard deviation from two sets of data:

$$\bar{s}(x) = \sqrt{\frac{(N_1 - 1)\,S^2(x_1) + (N_2 - 1)\,S^2(x_2)}{N_1 + N_2 - 2}}$$

5. Significance of difference between two means:

$$t \geq \frac{\left| \bar{x}_1 - \bar{x}_2 \right|}{\bar{s}\ (x)\sqrt{1/N_1 + 1/N_2}}$$

Interpretation: If $\bar{x}_1$ and $\bar{x}_2$ are the means of two samples from the same population, then, at a given value of t (from Tables), there is a 95% probability that the above inequality is valid, or conversely, if the inequality is true, it is probable that the samples are from the same population.

WHITE RIVER SHALE PROJECT

TRACE ELEMENT EVALUATION

TABLE I

RAW SHALE - OVERBURDEN

ELEMENT	MEAN PPM	STD. DEV. PPM	95% C.I. - POPULATION MEAN PPM
Drill Hole X-1: (9 Samples)			
B	21.74	13.74	11.18 - 32.30
Hg	0.09	0.02	0.07 - 0.11
Cd	0.08	0.02	0.06 - 0.10
F-	712.78	1758.04	0 -2064.13
Sb	0.25	0.11	0.17 - 0.33
As	8.95	7.50	3.19 - 14.72
Se	0.02	0.01	0.01 - 0.03
Pilot Drill Holes: (8 Samples)			
B	36.11	9.39	29.03 - 43.19
Hg	0.12	0.06	0.11 - 0.14
Cd	0.10	0.05	0.06 - 0.14
F-	766.44	493.07	394.67 -1138.21
Sb	0.37	0.13	0.27 - 0.47
As	18.00	7.48	15.0 - 23.7
Se	0.02	0.01	0.01 - 0.03

WHITE RIVER SHALE PROJECT

TRACE ELEMENT EVALUATION

TABLE II

RAW SHALE FROM MINING ZONE

ELEMENT	MEAN PPM	STD. DEV. PPM	95% C.I. - POPULATION MEAN PPM
Exploration Drill Holes: (9 Holes)			
B	22.93	17.43	9.53 - 36.32
Hg	0.16	0.04	0.13 - 0.19
Cd	0.18	0.03	0.16 - 0.20
F-	1505.55	857.12	846.71 - 2164.39
Sb	0.25	0.05	0.21 - 0.28
As	18.72	8.46	12.22 - 25.22
Se	0.11	0.04	0.08 - 0.14
Pilot Drill Holes: (4 Holes)			
B	24.13	3.57	18.45 - 29.80
Hg	0.11	0.03	0.07 - 0.15
Cd	0.32	0.39	0 - 0.95
F-	1022.0	449.77	306.42 - 1737.58
Sb	0.35	0.06	0.26 - 0.44
As	20.50	13.92	0 - 42.64
Se	0.04	0.04	0 - 0.10

WHITE RIVER SHALE PROJECT

TRACE ELEMENT EVALUATION

TABLE III

RAW SHALE FROM MINING ZONE

ELEMENT	U.S.G.S.** MEAN PPM	CCIC* MEAN PPM
B	95.00	23.30
Hg	0.12	0.15
Cd	0.60	0.22
F-	1850.00	1356.77
Sb	1.50	0.28
As	52.20	19.27
Se	1.25	0.09

* Figures for Exploration and Pilot Holes combined. (13 Samples)

** As reported by Desborough, Pitman and Huffman in U.S.G.S. Open-File Report 74-77.

WHITE RIVER SHALE PROJECT

TRACE ELEMENT EVALUATION

TABLE IV

RAW/SPENT SHALE FROM MINING ZONE
(9 Holes)

	RAW SHALE	SPENT SHALE	
ELEMENT	MEAN PPM	TOTAL MEAN* PPM	WATER SOLUBLE MEAN PPM
B	22.93	26.07	2.71
Hg	0.16	0.12	0.004
Cd	0.18	0.17	0.02
F-	1505.55	1816.67	903.88
Sb	0.25	0.33	0.03
As	18.72	12.38	8.92
Se	0.11	0.06	0.02

* Some elements, such as Boron, are not volatilized during the retorting process and, due to the overall weight loss in retorted shale, the net result is a higher concentration than observed in the corresponding raw shale.

WHITE RIVER SHALE PROJECT

TRACE ELEMENT EVALUATION

TABLE V

SPENT SHALE FROM MINING ZONE

EXPLORATION HOLES ONLY
(9 Holes)

ELEMENT	MEAN PPM	STD. DEV. PPM	95% C.I. - POPULATION MEAN PPM
Total Trace Elements:			
B	26.07	10.03	18.36 - 33.78
Hg	0.12	0.03	0.10 - 0.14
Cd	0.17	0.02	0.15 - 0.19
F-	1816.67	1521.92	646.82 - 2986.52
Sb	0.33	0.06	0.29 - 0.37
As	12.38	7.00	7.00 - 17.76
Se	0.06	0.03	0.04 - 0.08
Water Soluble Trace Elements			
B	2.71	1.60	1.55 - 3.87
Hg	0.004	0.002	0.002- 0.006
Cd	0.02	0.007	0.01 - 0.03
F-	903.88	291.67	679.68 - 1128.08
Sb	0.03	0.01	0.02 - 0.04
As	8.92	8.47	2.41 - 15.43
Se	0.02	0.01	0.01 - 0.03

CERTIFICATES OF ANALYSIS:

The following pages are the certified results of over 400 separate tests performed by Ute Research Laboratories. In all, a total of 54 samples taken from the 13 drill holes were analyzed for trace element concentrations.

UTE RESEARCH LABORATORIES

40 North 400 West
SALT LAKE CITY, UTAH 84103
Telephone (801) 359-3252

P. O. Box 119
FT. DUCHESNE, UTAH 84026
Telephone (801) 722-2254

Certificate of Analysis

Date: March 25, 1976

Client: Cleveland Cliffs

Sample Number: M-2083 Trace Element Samples

Date received:

Submitted by:

Samples analyzed for:

Results:

P-1	B	Hg	Cd	F	Sb	As	Se
500-600	34.0	0.05	0.03	480.0	0.5	12.0	.026
6- 7	46.0	0.22	0.03	602.0	0.4	16.0	.036
7- 8	29.0	0.12	0.91	1658.0	0.4	10.0	.010
8- 9	6.0	0.12	0.68	1170.0	0.3	5.0	.014
9- 10	13.0	0.16	0.11	644.0	0.6	20.0	.037
10- 11	14.0	0.14	0.11	680.0	0.4	6.0	.027
11- 12	8.0	0.12	0.10	434.0	0.4	29.0	.030

Remarks:

By M. Dale Slade

ALL VALUES REPORTED AS INDICATED

P-2 HOLE	B	Hg	Cd	F	Sb	As	Se
550-650	43.0	0.13	0.13	1115.0	0.3	23.0	.008
650-750	49.0	0.10	0.09	704.0	0.4	19.00	.020
750-850	13.0	0.08	0.16	1707.0	0.2	21.0	.026
850-950	28.0	0.08	0.04	319.0	0.4	61.0	.034
950-1050	26.0	0.22	0.04	705.0	0.3	39.0	.024
1050-1150	8.0	0.02	0.11	442.0	0.5	26.0	.020
1150-1250	28.0	0.07	0.08	886.0	0.4	23.0	.035
P-3 HOLE							
570-670	29.0	0.10	0.19	598.0	0.3	22.0	.014
670-770	28.0	0.06	0.10	648.0	0.2	3.0	.028
770-870	24.0	0.11	0.14	762.0	0.3	15.0	.017
870-970	17.0	0.06	0.12	762.0	0.3	18.0	.020
970-1070	3.0	0.12	0.12	384.0	0.2	27.0	.035
1070-1170	10.0	0.03	0.05	412.0	0.2	11.0	.011
P-4 HOLE							
460-560	33.0	0.21	0.14	680.0	0.4	25.0	.010
560-660	42.0	0.12	.09	894.0	0.6	24.0	.015
660-760	23.0	0.14	.13	655.0	0.4	16.0	.093
760-860	16.0	0.04	.08	516.0	0.3	10.0	.035
860-960	13.0	0.03	.11	428.0	0.2	11.0	.080
960-1060	8.0	0.02	.07	320.0	0.3	2.0	.035
1060-1160	7.0	0.03	.09	511.0	0.3	11.0	.023

M. Dale Slade

UTE RESEARCH LABORATORIES

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SALT LAKE CITY, UTAH 84103
Telephone (801) 359-3252

P. O. Box 119
FT. DUCHESNE, UTAH 84026
Telephone (801) 722-2254

Certificate of Analysis

Date: March 25, 1976

Client: Cleveland Cliffs

Sample Number: M-2878

Date received: 10 Raw Shales

Submitted by:

Samples analyzed for: Drill Hole X-1

Results:

Raw Shale	*B	Hg	Cd	F	Sb	As	Se	Mo
60-160	14.	0.06	0.06	170.	.139	2.29	0.01	0.35
160-260	8.45	.07	0.06	5400.	.157	1.71	0.01	0.29
260-360	12.5	.07	0.05	90.	.142	1.14	0.02	0.39
360-460	8.45	.10	0.07	85.	.152	0	0.02	0.40
460-560	25	.11	0.08	150.	.290	12.	0.03	0.80
560-660	19.2	.09	0.11	100.	.297	13.	0.04	0.72
660-760	20.75	.11	0.09	115.	.407	15.4	0.03	0.90
760-860	39.5	.11	0.12	180.	.434	18.	0.03	0.86
860-960	47.8	.11	0.10	125.	.251	17.	0.02	0.93
960-1163	24.0	.12	0.11	150.	.241	25.7	0.01	0.90
Spent Shale 963-1163	40.0	.05	0.13	1150.	.223	22.9	0.04	1.22
Spent Shale Water Soluble 963-1163	0	.004	0.01	910.	.020	0.29	0.01	0.40

Remarks: Results are in ppm.

*B-Boron, M-Mercury, Cd-Cadmium, F-Fluoride, Sb-Antimony, As-Arsenic, Se-Selemium, and Mo-Molybdenum.

By Dr. Dale Slade, Director

Dr. Dale Slade

ALL VALUES REPORTED AS INDICATED

UTE RESEARCH LABORATORIES

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SALT LAKE CITY, UTAH 84103
Telephone (801) 359-3252

P. O. Box 119
FT. DUCHESNE, UTAH 84026
Telephone (801) 722-2254

Certificate of Analysis

Date: March 25, 1976

Client: Cleveland Cliffs

Sample Number: M-2745

Date received: October 6, 1975

Submitted by:

Samples analyzed for: the following;

Results: Raw Shale from mining zone.

	X-2	X-3	X-4	X-5	X-6	X-9	X-10	X-11
Boron	7.10	14.7	9.50	52.0	52.05	8.45	20.1	18.50
Mercury	0.24	0.18	0.16	0.17	0.17	0.14	0.14	0.12
Cadmium	0.20	0.18	0.17	0.19	0.19	0.17	0.19	0.19
Flouride	1000.	1150.	1000.	1350.	1500.	1900.	3000.	2500.
Antimony	.377	.229	.245	.235	.208	.223	.239	.235
Arsenic	25.7	25.7	20.0	20.0	2.86	8.57	14.29	25.7
Selenium	0.11	0.15	0.10	0.11	0.13	0.15	0.11	0.12
Molybdenum	1.44	1.04	0.96	1.24	1.17	0.83	0.97	1.06

Remarks: Results are in ppm.

By M. Dale Slade

ALL VALUES REPORTED AS INDICATED

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Certificate of Analysis

Date: March 25, 1976

Client: Cleveland Cliffs

Sample Number: M-2745

Date received: October 6, 1975

Submitted by:

Samples analyzed for: the following;

Results: Spent Shale from mining zone.

	X-2	X-3	X-4	X-5	X-6	X-9	X-10	X-11
Boron	13.5	15.0	16.5	27.9	33.8	30.9	20.1	36.9
Mercury	0.10	0.12	0.14	0.14	0.14	0.13	0.12	0.13
Cadmium	0.17	0.16	0.18	0.17	0.20	0.18	0.19	0.19
Flouride	4500.	1050.	1000.	1050.	1050.	1050.	1000.	4500.
Antimony	.316	.307	.319	.323	.345	.380	.404	.392
Arsenic	5.71	8.57	14.29	14.29	20.0	0	11.43	14.29
Selenium	0.07	0.06	0.055	0.11	0.06	0.06	0	0.04
Molybdenum	1.23	1.35	1.22	1.34	1.26	1.23	1.22	1.30

Remarks: Results are in ppm.

By M. Dale Slade

ALL VALUES REPORTED AS INDICATED

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P. O. Box 119
FT. DUCHESNE, UTAH 84026
Telephone (801) 722-2254

Certificate of Analysis

Date: March 25, 1976

Client: Cleveland Cliffs

Sample Number: M-2745

Date received: October 6, 1975

Submitted by:

Samples analyzed for: the following;

Results: Spent Shale from mining zone.
Water Soluble

	X-2	X-3	X-4	X-5	X-6	X-9	X-10	X-11
Boron	1.9	3.4	5.2	1.7	3.4	1.4	3.1	4.3
Mercury	.008	.006	.003	.005	.004	.003	.003	.001
Cadmium	0.01	0.03	0.02	0.01	0.02	0.01	0.02	0.01
Flouride	850.	850.	900.	925.	1000.	1100.	250.	1350.
Antimony	.031	.016	.015	.022	.019	.057	.026	.028
Arsenic	0	14.29	0	11.43	11.43	17.1	22.86	2.86
Selenium	0.01	0.03	0.02	0.02	0.005	0.01	0.03	0.01
Molybdenum	0.68	0.55	0.46	0.50	0.69	0.56	0.69	0.64

Remarks: Results are in ppm.

By Dr. Dale Slade, Director

ALL VALUES REPORTED AS INDICATED

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White River Shal
trace element a

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